Quadriceps tendinosis and patellar tendinosis in professional beach volleyball players: sonographic findings in correlation with clinical symptoms

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Keywords Knee · Sports injury · Overuse injury · Ligament · Tendon · Tendinosis

Introduction

Beach volleyball is an increasingly popular sport and has been recognized as an Olympic sport since 1996. Overuse injuries in professional beach volleyball players represent an important source of disability and impaired performance [1]. The most affected body regions are the lower back, knee, and shoulder [1]. The knee is among the most frequent sites of overuse injuries in volleyball players, affecting more than 40% of high level volleyball players [2]. Repetitive jumping is typical in beach volleyball and the extensor apparatus of the knee is subject to continuous repetitive stress. The jumper's knee or patellar tendinosis is a well-known condition in athletes with high stress on the leg extensors [3, 4]. However, not only the patellar tendon but also the quadriceps tendon is subject to the same forces.

In our own experience, volleyball players often reported pain not only at the distal pole of the patella but also at the proximal pole of the patella and at the distal quadriceps tendon. There is only limited knowledge about overuse injuries of the quadriceps tendon in beach volleyball athletes.

The purpose of the study was to assess the frequency of quadriceps tendinosis and patellar tendinosis in professional beach volleyball players, comparing the dominant leg and the contralateral leg, and to correlate ultrasound findings with clinical symptoms.

Materials and methods

Data acquisition was performed during one of the grand-slam beach volleyball tournaments of the FIVB (Federation Internationale de Volleyball) world tour in Klagenfurt. All players were informed about the study during the technical meeting, which all teams were required to attend. They were invited to participate voluntarily at the study during the tournament. All examinations were performed on-site during the tournament in the medical treatment area. All players gave their informed consent. The study was approved by the local ethics committee. Only professional beach volleyball players participating actively at the tournament were included. The main draw of the tournament consisted of 32 women's teams and 32 men's teams. Additionally, 19 women's teams and 18 men's teams participated at the qualifications. This results in a total of 202 athletes (100 men and 102 women). Sixty-one athletes (30%) were included in the study, no athlete was excluded.

Clinical assessment

All players were examined by one of four experienced orthopedic surgeons. A standardized knee score (Lysholm knee score) [5] was assessed for both knees. The maximum value of the Lysholm score is 100 points: 100–96 is an excellent score, 95–84 is a good score, 83–65 is s a fair score and <65 is a poor score. Peripatellar pain while playing beach volleyball was rated by the player on a visual analogue scale (from "0" indicating no pain to "10" indicating worst pain imaginable) separately for both legs.

Sonographic assessment

Each athlete underwent a standardized examination for both knees. The sonographer was blinded to the symptoms and to which side is the dominant leg. To further reduce a possible bias of the sonographer 15 volunteers were randomly sent to the sonographic assessment additionally. These volunteers were recruited from the staff of the tournament but were not active beach volleyball players. The outfit of the volunteers was similar to that of the player group. The purpose of these additional examinations was to reduce a possible bias of the sonographer only. These additional examinations were not included in the data analysis.

Sonographic assessment was performed with a linear transducer (Toshiba Nemio 35, 8–14 MHz linear transducer, set to 12 MHz): length of field of view: 3 cm; depth: 4 cm; two foci were used. The examination was performed in a standardized fashion for both knees. The knee was positioned in a moderate flexion of about 45 degrees [6]. For the quadriceps tendon three sagittal images (patellar insertion, mid-tendon and musculo-tendinous junction), transverse images, as well as a power Doppler images in the same planes were obtained. For the patellar tendon three sagittal images (patellar attachment, mid-tendon, tibial attachment) transverse images and power Doppler images in the same planes were obtained.

Following criteria were assessed for the quadriceps and the patellar tendon in both knees: echo texture of the fibre structure was rated as "normal", defined by well visible fibrillar architecture, or as "abnormal" with loss the visibility of fibre texture. Hypoechoic foci within the tendon substance were recorded as "present" or "absent". A tendinosis was diagnosed based on the loss of the fibrillar architecture and/or the presence of hypoechoic foci within the tendon. The number of calcifications was counted. A calcification was defined as a hyperechoic area within the tendon substance with an associated acoustic shadowing. The number of independent areas with positive power-Doppler signals within the tendon was counted. The antero-posterior diameter of the quadriceps tendon and the patellar tendon was measured at the attachment of the patella.

Statistics

All data analysis was performed using statistical software (SPSS, version 11; SPSS, Chicago, Ill.). P values less than 0.05 were considered statistically significant.

The Wilcoxon signed-ranks test was used to test if continuous and ordinal variables have the same distribution between the dominant and the non-dominant leg. For nominal variables the Fisher's exact test was used.

Multiple linear regression was performed to estimate which of the sonographic variables (independent variables) best predict the amount of pain during the game (dependent variable). The multiple regression analysis was preformed for both the dominant and the non-dominant leg separately. The threshold of significance, which was the criterion for entry into the model, was set at .05.

The Mann-Whitney U-test was used to compare continuous data between tendons with tendinosis and tendons without tendinosis.

Results

Demographic data of athletes

Sixty-one athletes (38 male athletes, mean age 29.6 years, range 20–36 years; 23 female athletes, mean age 27.1 years, range 20–39) were included in the study. The dominant leg was right in 51 athletes (84%) and left in ten athletes (16%).

Clinical and sonographic findings in the dominant leg and the non-dominant leg

Clinical and sonographic findings of the dominant leg and the non-dominant leg are listed in Table 1. Examples of sonographic findings are shown in Figs. 1 and 2. Quadriceps tendinosis was diagnosed in 13 athletes (21%) at the dominant leg and in 21 athletes (34%) at the non-dominant leg. Patellar tendinosis was diagnosed in 13 athletes (21%) at the dominant leg and in 18 athletes (30%) at the non-dominant leg. Differences between the dominant and the non-dominant leg were not significant (Table 1).

Multiple regression analysis

Only sonographic findings of the quadriceps tendon significantly predicted peripatellar pain during sports: thickness of the quadriceps tendon (significant for both legs, P=0.011/P=0.030), abnormal echo texture (dominant leg P=0.001), power-Doppler signal (dominant leg: P=0.049), calcifications (non-dominant leg, P= 0.021) (Table 2). We were not able to demonstrate a relationship between findings at the patellar tendon and symptoms.

Table 1 Clinical and sonographic findings of the dominant leg and the non-dominant leg

Continuous data									
	Dominant leg				Non-dominant leg				
	Mean	Min	Max	SD	Mean	Min	Max	SD	P^a
Clinical assessment									
Lysholm score	92	64	100	11	93	64	100	10	0.91
VAS dominant	1.5	0	10	2.5	1.7	0	10	2.7	0.80
Quadriceps tendon									
Diameter (mm)	6.9	4.5	12.7	1.5	7.1	4.7	12.8	1.8	0.21
Calcifications (*n*)	0.9	0	5	1.4	1.1	0	5	1.7	0.06
Power Doppler (*n*)	0.3	0	4	0.7	0.4	0	4	1.0	0.12
Patellar tendon									
Diameter (mm)	5.3	3.0	12.0	1.6	5.5	3.2	10.1	1.5	0.09
Calcifications (*n*)	0.2	0	5	0.8	0.3	0	3	0.7	0.22
Power Doppler (*n*)	0.1	0	3	0.5	0.3	0	3	0.8	0.11

Nominal data			
	Dominant leg *n* (%)	Non-dominant leg *n* (%)	P^b
Quadriceps tendon			
Echotexture:			
Loss of fibre visibility	11 (18)	16 (26)	0.12
Hypoechogenic foci	5 (8)	13 (21)	0.07
Presence of calcifications	24 (39)	26 (43)	0.84
Patellar tendon			
Echotexture:			
Loss of fibre visibility	10 (16)	13 (21)	0.64
Hypoechogenic foci	7 (11)	10 (16)	0.60
Presence of calcifications	12 (20)	8 (13)	0.46

[a] Wilcoxon signed-rank test
[b] Fisher's exact test

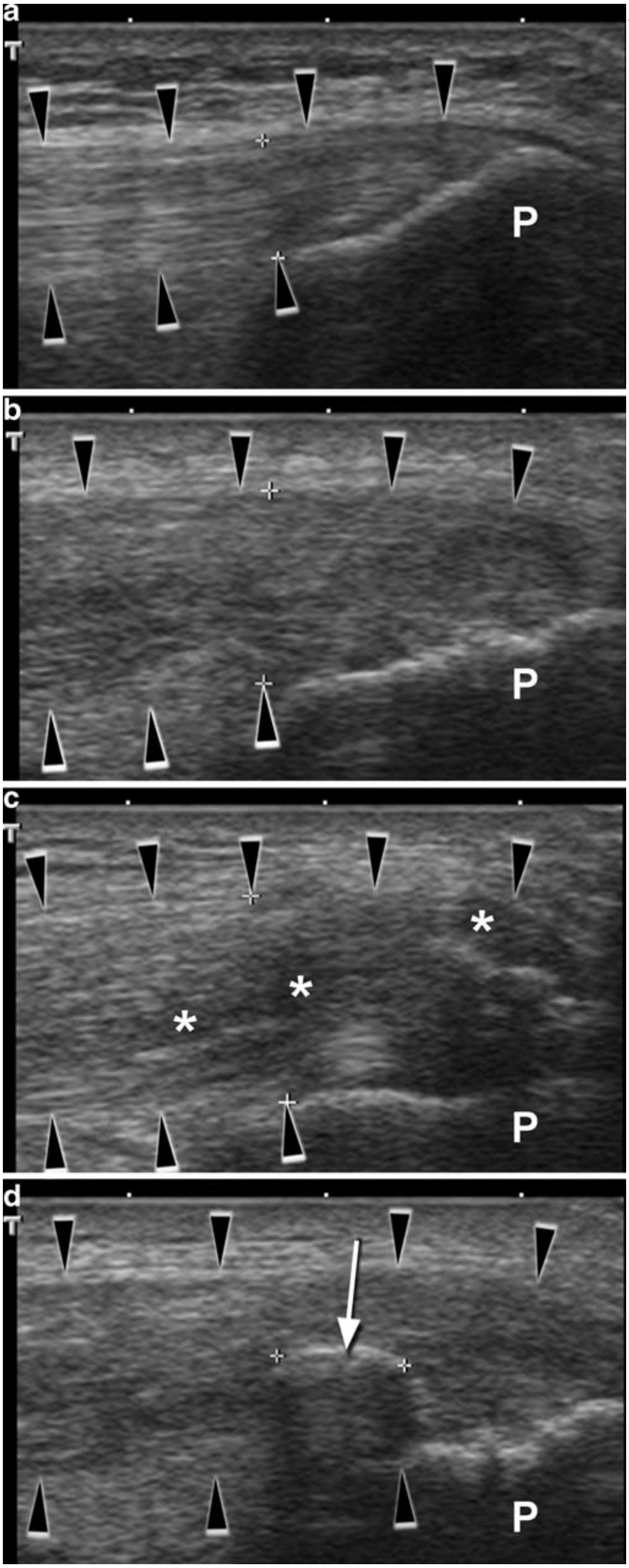

Fig. 1 Sagittal sonograms of quadriceps tendons (*black arrowheads*): (**a**) normal, (**b**) thickening of the tendon and loss of fibre structure, (**c**) hypoechogenic foci (*asterisk*), (**a**) calcification with acoustic shadowing. (*P* patella)

Tendon diameter

Mean quadriceps tendon thickness with tendinosis was 8.4 mm/8.5 mm (dominant leg/non-dominant leg), in normal tendons 6.4 mm/6.4 mm (P<0.001/P<0.001). Mean patellar tendon thickness with tendinosis was 7.6 mm/7.0 mm, in normal tendons 4.7 mm/4.8 mm (P<0.001/P=0.001) (Table 3).

Discussion

Early report about jumper's knee described involvement of the quadriceps and patellar tendon [7, 8]. In most subsequent investigations the term jumper's knee is used synonymously for the overuse syndrome of the patellar tendon [9–12]. Our data suggest that, unlike in many other jumping sports [13], beach volleyball affects both the patellar and the quadriceps tendon. In our study population, the frequency of patellar tendon and quadriceps tendon involvement was comparable with other previous reports [4, 13–15]. Quadriceps tendinosis and tears have rarely been reported as an overuse syndrome in high-performance athletes [16, 17]. This condition seems to be rather typical for beach volleyball athletes.

Calcifications were surprisingly frequent within the quadriceps tendon of our high performance volleyball players. Frequency of calcifications within the patellar tendon was considerably lower. The number of calcifications within the quadriceps tendon was also one of the significant factors predicting the amount of peripatellar pain during the game in the non-dominant legs. Calcification is not a common reaction of a tendon to chronic repetitive stress. Calcification is also not a common phenomenon of tendon degeneration or tendon tearing. Calcifications within the quadriceps tendons have been reported in renal failure and secondary hyperparathyroidism [18] and occasionally within a soft-tissue mass with calcification representing the retracted quadriceps tendon in cases with complete quadriceps tendon tears [19]. Calcifications may be the results of a chronic inflammatory process as reaction to chronic repetitive tendon injury. Calcifications are a remarkable feature of quadriceps tendon overuse in beach volleyball athletes.

Although expected, dominant leg versus non-dominant leg did not have an influence on the frequency of tendon overuse syndromes. Both the clinical assessment and the sonographic evaluation revealed symmetric distribution. One possible reason that training is focused on both sides equally.

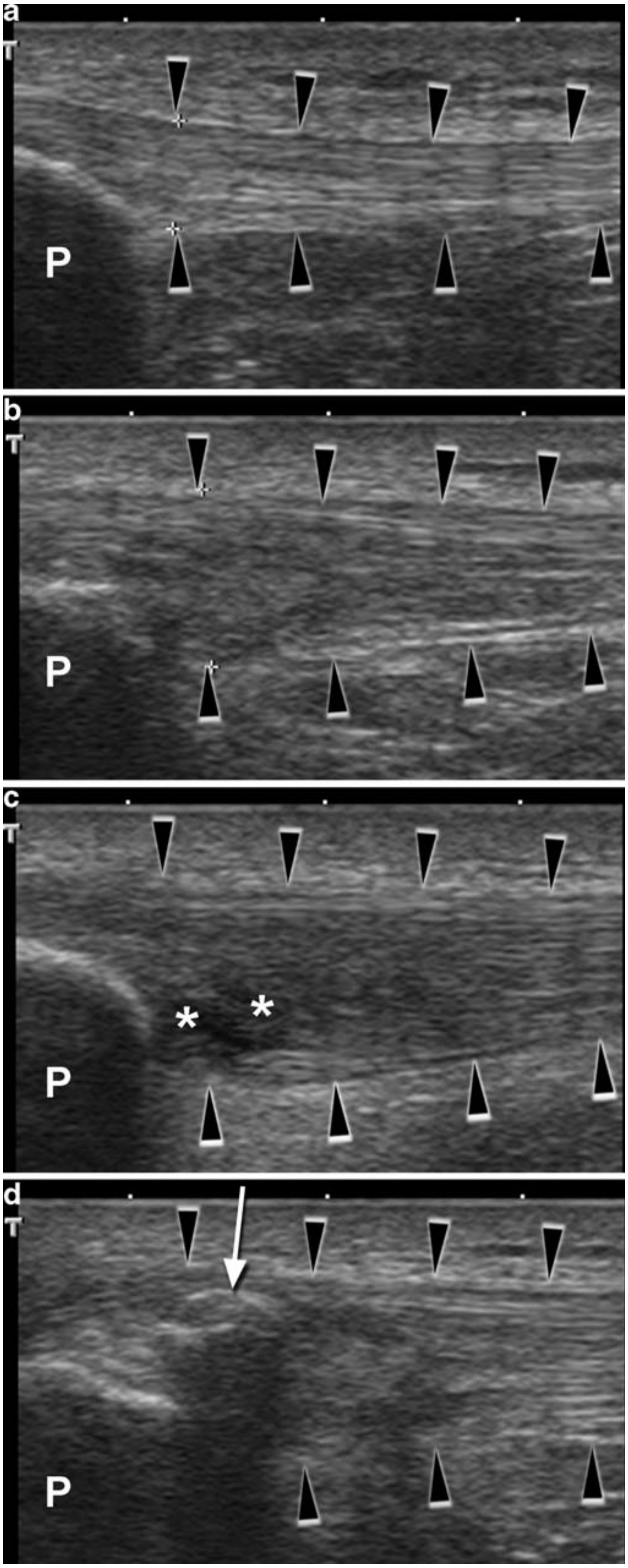

Fig. 2 Sagittal sonograms of patellar tendons (*black arrowheads*): (**a**) normal, (**b**) loss of fibre structure, (**c**) hypoechogenic foci (*asterisk*), (**d**) calcification with acoustic shadowing. (*P* patella)

Aagaard and Jorgensen [20] reported an overall incidence of 3.8 injuries per player per 1,000 volleyball hours played. In their comprehensive assessment, Bahr and Reeser [1] were able to assess 95% of all beach volleyball players participating at five consecutive tournaments similar to the tournament of our study. They reported 54 acute injuries. Injuries to the knee (30%), ankle (17%), and finger injuries (17%) were most common. Sixty-seven players reported 79 overuse injuries. The three most common affected regions were the low back (19%), the knee (12%), and the shoulder (10%). In our study population, the frequency of quadriceps tendinosis (21–34%), the frequency of patellar tendinosis was (21–30%) considerably higher. In our study we were able to examined about one-third of the players of the tournament. Symptomatic players were probably more likely to participate at our study; therefore, some selection bias has probably been introduced, explaining the higher frequency in our data.

The normal quadriceps tendon has a hyperechoic, multi-laminar, structure at sonography [6]. The multi-laminar sonographic appearance is explained by the presence of two to four tendon layers. Most commonly three layers are present. The superficial layer originates from the posterior fascia of the rectus femoris muscle. The deep layer originated from the anterior fascia of the vastus intermedius muscle. The middle layer arises from the fascia between the vastus intermedius and the vastus lateralis and vastus medialis [21]. Sonography has been reported as a sensitive and specific tool in the evaluation of quadriceps tendon rupture [6, 22]. In a study using MR arthrography, the thickness of a normal quadriceps tendon measured between 7 and 8 mm [23], In our study using ultrasound, the mean thickness of normal tendons was lower (6.4 mm).

Ultrasound is recommended as the initial investigation in the assessment of patients with overuse syndrome of the patellar tendon [24]. The normal sonographic appearance shows a hyperechoic regular band with well-defined borders and homogeneous internal fibrillar echo texture. Contrarily to the quadriceps tendon, no internal tendon laminae are present [25]. The normal patellar tendon should not exceed 7 mm [26]. The mean diameter of the tendons with tendinosis was between 7 and 7.6 mm in our study.

Normal tendons do not show power-Doppler signals within the tendon substance. Positive power-Doppler signals indicate the presence of neovascularization in abnormal patellar tendons, which is associated with greater tendon pain compared with abnormal tendons without neovascularization [27, 28]. Positive power-Doppler signals were also significant predictors for pain in the dominant leg in our data.

Table 2 Multiple regression to estimate which of the sonographic variables (independent variables) best predict the amount of peripatellar pain during the game (dependent variable)

	Beta	Standard error	*P*
	Dominant leg		
Quadriceps tendon			
Diameter	0.397	0.250	0.011
Echotexture	0.461	0.561	0.001
Calcifications	0.035	0.297	0.835
Power Doppler	−0.379	0.650	0.049
Patellar tendon			
Diameter	0.055	0.274	0.750
Echotexture	0.255	0.551	0.083
Calcifications	−0.380	0.971	0.201
Power Doppler	0.088	1.493	0.752
	Non-dominant leg		
Quadriceps tendon			
Diameter	0.427	0.292	0.030
Echotexture	0.246	0.653	0.228
Calcifications	−0.421	0.283	0.021
Power Doppler	0.150	0.440	0.346
Patellar tendon			
Diameter	−0.208	0.307	0.239
Echotexture	0.227	0.504	0.117
Calcifications	0.025	0.529	0.864
Power Doppler	0.085	0.465	0.537

In a study assessing the relationship between symptoms of jumper's knee and the ultrasound characteristics of the patellar tendon among high-level male volleyball players, Lian and co-workers did not find specific ultrasound findings correlating significantly with the degree or the duration of symptoms [29]. This is in line with the results of our analysis. Ultrasound findings about the patellar tendon did not significantly predict peripatellar pain during the beach volleyball game. However, findings in the quadriceps tendon, especially thickening of the tendon, did significantly predict symptoms.

Several study limitations have to be considered. There is a possible selection bias as symptomatic players were probably more likely to participate in our study. We were not able to find an association between findings at the patellar tendon and symptoms, which may be because of the relatively low sample size. We tried to minimize any possible bias of the sonographer. The sonographer was blinded to the symptoms of the athletes and volunteers

Table 3 Comparison of the tendon diameter between normal tendons and tendons with tendinosis

	Normal			Tendinosis			
	n	Mean (mm)	SD (mm)	*n*	Mean (mm)	SD (mm)	P^a
Quadriceps tendon							
Dominant leg	48	6.4	0.9	13	8.4	2.1	<0.001
Non-dominant leg	40	6.4	1.0	21	8.5	2.0	<0.001
Patellar tendon							
Dominant leg	48	4.7	0.8	13	7.6	1.7	<0.001
Non-dominant leg	43	4.8	0.8	18	7.0	1.7	0.001

[a]Mann-Whitney *U*-test

were randomly mingled to the study population. Nevertheless there might be some bias introduced by the direct interaction of the sonographer and the athlete during the examination. In our study, the knee was positioned in a moderate flexion of about 45 degrees for the sonographic evaluation. The flexed position of the knee may lead to tension within the tendons and therefore to a lower sensitivity to detect neovascularity using power-Doppler sonography.

In conclusion, quadriceps tendinosis is as common as patellar tendinosis in professional beach volleyball players. Quadriceps tendinosis appears to be clinically more relevant than patellar tendinosis. Thickening and structure alteration of the quadriceps tendon is associated with anterior knee pain during elite beach volleyball.

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